
CHAPTER 4: Troubleshooting

System Diagnostics

The AutoCAT®2's diagnostic alarm system continuously monitors operating conditions. The AutoCAT®2 is able to detect and alert you to many conditions that require a response. When an alarm condition occurs, the AutoCAT®2 displays a message, including suggested corrective actions. Press the ALARM RESET control key to reset the audio tone. Possible causes and corrective actions are listed at the end of this chapter. ALARM RESET must be pressed prior to re-initiating pumping. If multiple alarms have been issued, the ALARM RESET key must be pressed once for each alarm present.

The contents of this chapter include:

CHAPTER 4: Troubleshooting 4-1

4.1: Troubleshooting	4-3
Alarm Detection and Classification	4-3
Alarms	4-4
Alarm Control Keys	4-5
Class 1 Alarm Criteria	4-6
Class 2 Alarm Criteria	4-10
Class 3 Alarm Criteria	4-11
Class 4 Alarm Criteria	4-13
4.2: Troubleshooting Guidelines	4-14
Troubleshooting Guidelines	4-14
Common Operational Problems	4-14
Troubleshooting ESIS	4-23
Troubleshooting Diagnostic Alarm	4-25
4.3: Balloon Pressure Waveform	4-35
Balloon Pressure Waveform	4-35
Squared Waveform	4-36
Reduced Augmentation	4-37
Baseline Below Zero	4-38
4.4: Leak Testing and Tubing Repairs	4-39
Leak Test and Tubing Repair	4-39

The AutoCAT®2 is designed to the highest standards of reliability. However, specific patient states, operating conditions or pump malfunctions can cause shut down of pumping action. Pump shut down requires immediate staff action. The pneumatic control system automatically vents, deflating the balloon to a hemodynamically safe level. However, allowing the balloon to remain in place while deflated in excess of 30 minutes is hazardous. Blood can become trapped in the folds of the deflated balloon material and thrombus formation may occur. To aid the staff in identifying the cause of a shutdown, thereby reducing pump down-time, the AutoCAT®2 has computerized diagnostics. The display will automatically display pre-programmed alphanumeric messages that identify the problem and suggest procedural steps for immediate correction. When a shutdown occurs, the time should be noted; hospital personnel knowledgeable in the maintenance of this equipment should immediately be called. If repair and pumping cannot be accomplished within 30 minutes, or another console is not available for use, balloon removal should be accomplished as soon as possible. To further reduce the danger of thrombus formation, a 50/60 cc syringe should be connected to the balloon catheter and inflate and deflate the balloon rapidly with air several times every 10 minutes. This procedure will aid in preventing the formation of thrombus but should be used only as an emergency procedure for short periods of time while awaiting the physician's arrival. It is strongly recommended that each hospital have more than one IABP available, so that a backup pump can be substituted in the event of a major pump shutdown. The following text describes the diagnostic messages, their cause of occurrence and steps to be taken to correct the shutdown. The AutoCAT®2 IABP operator's manual further elaborates system diagnostics.

Alarm Detection and Classification

The AutoCAT®2 detects more than 40 alarm conditions, which are grouped in 4 alarm classifications. Each alarm is classified in order of its priority and each alarm, based on its classification, will result in specific consequences when it occurs. In other words, some alarms cause the pump to default to pump STOP; some cause the pump to default to PUMP STANDBY and some simply display a message.

4. Troubleshooting

4.1: Alarm Classification

ALARMS (in order of priority, grouped according to classification)

Class 1: Causes Pump STOP

1. System Error
- *2. Unable to Refill
- *3. Possible Helium Leak
- *4. High Pressure
- *5. High Baseline
- *6. Large Helium Leak
- *7. Purge Failure

Class 2: Causes Pump STANDBY

8. Standby Alarm Disabled
9. Standby longer than 3 minutes
10. ECG Fault Lead Detected
- **11. ECG Trigger Loss
- **12. Pressure Trigger Loss
13. Trigger Loss

Class 3: Causes Audio ALARM and Visual Message Display

14. AP FOS Signal weak
(AutoCAT[®]2 WAVE only)
15. AP FOS CAL Key missing or corrupt
(AutoCAT[®]2 WAVE only)
16. AP FOS Sensor Out of Range
(AutoCAT[®]2 WAVE only)
17. Drain Failure
18. Deflation 100%
19. Timing Error
20. Battery Inoperative
21. Battery life less than 5 minutes
22. Battery life less than 10 minutes
23. Battery life less than 20 minutes
24. System Running on Battery Power
25. ECG Detected during Internal Trigger
26. Weaning Step Complete
27. Arterial Pressure Alarm
28. Low Helium Supply

Class 4: Visual Message Only

29. Possible Late Deflation
30. Erratic Triggering
31. ECG Lead Fault
32. No ECG Signal Available
33. No AP Signal Available
34. Arrhythmia Timing Not Available
35. Warning: Dead Clock Battery
36. Warning: Low Battery for
Static Alarm

ALARM AUDIO TONES

Each alarm classification has its own distinct audio tone.

Class 1: ALARM - Highest pitch audio tone with rapid interrupted beeps.

Class 2: ALARM - Lower pitch audio tone with slower interrupted beeps.

Class 3: ALARM - Lowest pitch audio tone with slowest interrupted beeps.

Class 4: No audio tone

* ALARMS OFF disables these alarms only.


** When the alarms are off, the time required to initiate these alarms is extended from 8 seconds to 30 seconds.

Alarm Control Keys

ALARMS ON

Pressing the ALARMS ON/OFF key will turn on all of the alarms if they had previously been turned off.

ALARMS OFF

The AutoCAT®2 offers the operator the ability to disable certain alarms for a period of time. To disable the alarms, press the alarm ALARMS ON/OFF key. A menu will be displayed along the bottom of the LCD allowing the operator to select the amount of time for the alarms to be off. Once a selection is made, the alarms will be disable for that period of time. The LED on the ALARMS ON/OFF key will flash when the alarms are off. Also, a  symbol will be displayed on the LCD, along with a counter showing the time remaining in the alarms off mode.

In the standard configuration, the maximum amount of time that can be selected for the alarms to be off is 60 minutes. However, if option switch #3 on the CPU PCB is ON, the ability to permanently disable the alarms is enabled.

ALARM RESET

Activation of the ALARM RESET key will cause the AutoCAT®2 to silence the alarm audio tone. After the operator has corrected the cause of the alarm condition, balloon pumping can resume.

NOTE: (The alarm message will remain until pumping is resumed).

AUDIO LEVEL

Allows volume changes in 10% increments for the alarm keys.

4. Troubleshooting

4.1: Alarm Classification

The Class 1 alarms which are described in the following section, will cause the system to react in the following manner:

- Lights the Alarm Reset LED
- Freezes the LCD
- Stops the Pump and goes to the pump off mode
- Deflates the Balloon
- Opens the Vent Valve.
- Sounds an Audible Tone.
- Displays a Diagnostic Message

Prints approximately the last ten (10) seconds of the Arterial Pressure and Balloon Pressure waveform, patient hemodynamic data and the alarm condition.

CLASS 1 ALARM CRITERIA

1. System Error

System Error alarms have been divided into eight (8) categories with additional sub alarms. These sub alarms will not be obvious to the user. The alarm identification will appear on the recorder strip and will be used as a diagnostic aid for the service engineer or an authorized representative. Sub alarms or codes will appear only on the display.

SYSTEM ERROR 1

Balloon Pressure greater than 50 mmHg for longer than 1.8 seconds.

SYSTEM ERROR 3

Pump controller failure.

Subcodes:

1. Bellows cannot move away from HOME position.
2. Bellows cannot move to HOME position.
3. At start of inflation stroke bellows is at HOME position.
4. Stepper stroke failed to complete in 500 milliseconds.
5. CPU-PUMP serial communication failure.

SYSTEM ERROR 4

Main CPU failure

Subcodes:

10. Bus error.
11. Spurious interrupt.
12. Address error.
13. Illegal instruction.
14. Zero division.

15. Real time clock watchdog.

16. Trace trap.

SYSTEM ERROR 6

Front End failure.

All fault (subcodes) indicates consecutive fault detection for 5 seconds.

Subcodes:

1. FEB data packet rates out of range more than 2%.
2. FEB RAM failure.
3. FEB ROM failure.
4. FEB program logic fault.
5. FEB->CPU data packet out of sequence.

SYSTEM ERROR 7

Keyboard Controller failure.

Subcodes:

1. Keyboard controller fails to startup.
2. Keyboard controller not responding to CPU command.
3. Keyboard controller fails to reset.
4. Invalid key code received.
5. Bad keyboard data packet received.
6. CPU->FEB command packet out of sequence.
7. CPU-FEB serial communication failure.
8. Received FEB data packet rate is far lower than normal, suspected fatal CPU program failure.
9. FEB ADC 12V reference out of range 2 seconds in a row.
- 10 or >. Stuck key detected. A key is considered stuck when its key dome is continuously closed for longer than specific limits. If the key is a single action key this limit is 30 seconds, if the key is a repeat action key this limit is 60 seconds.

SYSTEM ERROR 8 (AutoCAT®2 Wave units only)

FOS board failure

Subcodes:

1. FEB hasn't received any FOS data packet for some time.
2. Received Instrument error message from FOS.

4. Troubleshooting

4.1: Alarm Classification

3. Received FOS RS232 error message from FOS.

4. Received ongoing self test message from FOS.

UNABLE TO REFILL

Failure to fill helium to target level of 2.5 mmHg (usually after a drain task).

Subcodes:

1. Fill rate is extremely slow.

2. Cannot fill to target for 30 seconds since refill started, in any triggering mode except AFIB. Cannot fill to target for 60 seconds since refill started, in AFIB triggering mode. POSSIBLE HELIUM LOSS

POSSIBLE HELIUM LOSS

System requests a third refill within two minutes of the last refill.

POSSIBLE HELIUM LOSS (3)

Balloon Pressure baseline before inflation is below -10mmHg for two consecutive beats.

Possible causes for both large helium leaks and possible helium loss are leaks in the tubing, balloon connections, catheter, vent hole or balloon. Check all connecting points along the catheter and tygon tubing down to the insertion point for any leaks. If all connections appear tight and no leak is apparent, a leak test can be performed.

Leak Test

1. Press the RESET control key in the ALARMS field to silence any audible alarms.
2. Press the ALARMS OFF control key twice and then select the amount of time for the alarm to be off.
3. Use a pair of rubber-shod hemostats or other clamping device to clamp the catheter tubing between the quick connect valve and the bifurcation.
4. Press the ON control key to start pumping.
5. Observe the balloon pressure waveform. If the baseline falls, the leak is probably between the pump and the clamp. If the baseline does not fall, the leak is probably on the patient side: consider stopping the pump, removing the balloon catheter and inserting another catheter.
6. Press the PUMP OFF control key and remove the hemostat.
7. Check the O-rings on the balloon connector, wipe off any debris and make sure that the connection at the quick connect valve is tight.

Also, examine the tubing at the balloon connector and at the catheter junction. If the tubing appears to be stretched in either location, see the instructions below to repair the tubing.

8. Repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, the leak is in the control system or the connector. Complete steps 9-10.

9. Press the PUMP OFF control key and remove the hemostat.
10. Remove the balloon connector, cut off 1/2" of tubing, replace the connector and repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, there may be an internal console leak. Call Arrow International for service.
11. If the alarms are still disabled, press the ON control key to re-enable the alarms.
12. Press ALARM RESET to remove alarm messages.

Tubing Repairs

1. To repair a tubing leak, wrap non-porous tape (e.g., electrical tape) around the tubing at the site of the leak.
2. To repair stretched tubing at the balloon connector, remove the compression ring and pull the connector off the tubing. Then cut off a 1/2 inch segment from the end of the tubing and reconnect the balloon connector and the compression ring.
3. To repair stretched tubing at the catheter junction, disconnect the tubing from the junction. Then cut a 1/2 inch segment from the end of the tubing and reassemble the junction.

If the leak is found at the QUICK CONNECT, Op-Site® or other occlusive, clear dressing material may be used to repair the leak.

HIGH PRESSURE

Balloon Pressure plateau pressure exceeds 250 mmHg, either for 5 consecutive beats, or for at 10 beats in the most recent 20 beats.

Subcodes:

1. Condition occurred in non-AFIB triggering mode.
1. Condition occurred in AFIB triggering mode.

HIGH BASELINE

Balloon Pressure baseline prior to inflation is higher than 25 mmHg.

Subcodes:

1. Condition occurred in triggering mode other than AFIB and inflation timing is less than 100%.
2. Condition occurred in triggering mode other than AFIB and inflation timing is at least 100%.
3. Condition occurred in AFIB triggering mode.

4. Troubleshooting

4.1: Alarm Classification

LARGE HELIUM LEAK

A large helium leak is detected.

Subcodes:

1. Balloon Pressure plateau is less than 5mmHg.
2. Balloon Pressure plateau is less than 1/8th of BP peak 5 beats ago.
4. Balloon Pressure peak for current beat is < half of peak 5 beats ago.

Subcodes are additive, for example, if causes for both subcodes 1 and 2 are detected the subcode will be 3.

PURGE FAILURE

System fails to complete the initial purge cycle within 8 seconds.

The Class 2 alarms which are described in the following section will cause the system to react by:

- Stopping the pump and going to the pump standby mode.
- Deflating the balloon.
- Leaving the vent valve closed.
- Sounding an audible tone.
- Displaying a diagnostic message.

CLASS 2 ALARM CRITERIA

STANDBY ALARM DISABLED

STANDBY alarm has been disabled by the user.

STANDBY LONGER THAN 3 MIN

System has been in STANDBY status for longer than 3 minutes.

ECG LEAD FAULT (Lead)

In OPERATOR MODE: ECG skin lead (s), or ECG lead cable trunk, or ECG cable Nicolay connector disconnected, or 3-lead cable is connected or cable is defective.

ECG TRIGGER LOSS

In OPERATOR MODE: While pumping in an ECG trigger mode, relevant trigger was not detected for 8 seconds if alarms are enabled, or 30 seconds if alarms are disabled.

PRESSURE TRIGGER LOSS

In OPERATOR MODE: While pumping in AP triggering mode, AP trigger was not detected for 8 seconds if alarms are enabled, or 30 seconds if alarms are disabled.

TRIGGER LOSS

In AUTOPILOT™ MODE: Can't find any ECG, AP or PACER trigger, on any of the ECG or AP signal sources.

The Class 3 Alarms which are described in the following section will cause the system to react by:

- Sounding an Audible Tone.
- Displaying a Diagnostic Message.

NOTE: Pumping is not stopped but action is required.

CLASS 3 ALARM CRITERIA

AP FOS SIGNAL WEAK (AutoCAT®2 Wave units only)

FOS catheter is not connected to the pump, or the light received from sensor is low due to a bad sensor, broken (kinked) fiber optic line or dirty connector.

AP FOS CAL KEY MISSING OR CORRUPT (AutoCAT®2 Wave units only)

The FOS Catheter Calibration Key is not inserted or corrupt.

AP FOS SENSOR OUT OF RANGE (AutoCAT®2 Wave units only)

The FOS Catheter has at least one of the following problems:

1. AD Ratiometric Error exists.
2. Pressure is outside Barometric pressure limits
3. FOS Optical Block temperature exceeds limits.
4. Pressure is outside pressure limits.
5. There is an excessive pressure offset.
6. FOS indicating strong light from sensor.

DRAIN FAILURE

Drain task has failed to complete after 8 tries to open drain valve.

DEFLATE MARKER SET BEYOND 100 PERCENT

In OPERATOR MODE: In any ECG triggering mode except AFIB, deflation timing is set at or beyond 100%.

TIMING ERROR

In OPERATOR MODE: Timing has been set such that deflation-to-inflation duration is less than 100 milliseconds. This is current rhythm dependent.

WARNING BATTERY INOPERATIVE

Battery power circuit breaker is tripped or open.

AVAILABLE BATTERY POWER LESS THAN 5 MINUTES

Amount of battery power remaining to operate the system is less than 5 minutes, power-down is imminent.

4. Troubleshooting

4.1: Alarm Classification

AVAILABLE BATTERY POWER LESS THAN 10 MINUTES

Amount of battery power remaining to operate the system is less than 10 minutes, power-down is imminent.

AVAILABLE BATTERY POWER LESS THAN 20 MINUTES

Amount of battery power remaining to operate the system is less than 20 minutes.

SYSTEM RUNNING ON BATTERY POWER

AC power source had become unavailable, system is running on battery.

VALID ECG TRIGGERS DETECTED

In OPERATOR MODE: Valid ECG triggers are detected when the system is in INTERNAL triggering mode.

WEANING STEP COMPLETE

The currently programmed weaning step has been completed.

ARTERIAL PRESSURE ALARM

AP has fallen below set alarm limit.

LOW HELIUM TANK PRESSURE

Helium tank pressure is less than 100PSI.

The Class 4 Alarms which are described in the following section will cause the system to react by:

Displaying a Diagnostic Message.

CLASS 4 ALARM CRITERIA

POSSIBLE LATE DEFLATION

In AUTOPILOT MODE: Deflation time is long (due to slow balloon), or Pre-Ejection Period (PEP) is too short while in ECG trigger mode.

ERRATIC TRIGGERING

In AUTOPILOT MODE: Cannot find a reliable ECG source to trigger on. Pump switches leads at least 4 times within one minute.

ECG LEAD FAULT (lead)

In AUTOPILOT MODE: ECG skin lead (s), or ECG lead cable trunk, or ECG cable Nicolay connector disconnected, or 3-lead cable is connected, or cable defective.

In OPERATOR MODE: Inactive ECG skin lead(s) has a lead fault.

NO ECG SIGNAL AVAILABLE

In AUTOPILOT MODE: There is no ECG trigger, or the lead is noisy, or has a lead fault on the 5 ECG sources: I, II, III, V and Monitor

NO AP SIGNAL AVAILABLE

In AUTOPILOT MODE: There is no AP trigger on any of the 3 AP sources: Xducer, Monitor, and FOS.

ARRHYTHMIA TIMING NOT AVAILABLE

In AUTOPILOT MODE: Pump can not select AFIB trigger mode although there is arrhythmia present and arrhythmia timing is ON, due to bad PEAK scores on all leads.

WARNING: DEAD CLOCK BATTERY

Real time clock backup battery cannot refresh real time clock RAM.

WARNING: LOW BATTERY FOR STATIC RAM

Power-on self test indicates that the RAM cell will not hold a test pattern, suspected RAM backup battery low.

4. Troubleshooting

4.1: Common Operational Problems

The troubleshooting tables in this chapter are designed to help you identify and correct problems quickly. In addition, you can identify and correct helium leaks by following the Leak Testing procedure described in section 8.4. If you are unable to correct EMI or any other problem with your system, call your local Arrow International Field Service Representative or call our 24-hour IABP service hotline 1-800-447-IABP (4227) or 1-617-389-8628 (outside the U.S.A. and Canada).

In addition, help is available for most functions. Simply press the HELP key for startup help or press HELP then a function key for specific key-related information.

Common Operational Problems

The table below describes the possible causes and corrective actions for many common operational problems. Where appropriate, there are references to sections in this manual for further information. If you do not find your problem in this table look in the other troubleshooting tables in this section. Always respond immediately to a pump shutdown.

COMMON OPERATIONAL PROBLEMS		
Problem	Possible Cause(s)	Corrective Actions
Console does not turn on when power switch is pressed	CPU does not start up	Power pump OFF then ON. If problem persists use another console. Contact field service.
	Console fuse blown	Contact qualified hospital personnel or your Arrow International Field Service Representative; use correctly rated fuses only
Pump operates in AC power but does not operate in battery	Circuit breaker switched off	Console not connected to AC and circuit breaker off. Switch on circuit breaker in helium compartment.
Pump does not power On when Low Battery Condition is present.	Battery voltage is below operating threshold	<ul style="list-style-type: none">• Plug pump into AC power source. Pump should Power On automatically.• If pump does not power on automatically, press power OFF then ON.• Press Pump On to resume pumping.• Call Field Service if problem cannot be resolved
No audible tone for control keys	Volume control too low	Use AUDIO LEVEL in multi-function keys to raise the volume (Section 3.3). Key tone and alarm tone may be set independently.
	Key Click off	Turn on Key Click.
No flashing heart symbol on LCD	Invalid trigger selected	Change trigger mode.
	ECG too small	Autogain may be insufficient—increase ECG gain via >GAIN key—consider using MAN GAIN.

4. Troubleshooting

4.1: Common Operational Problems

COMMON OPERATIONAL PROBLEMS		
Problem	Possible Cause(s)	Corrective Actions
No ECG waveform displayed	Incorrect ECG source selected	Check ECG signal source, then select that ECG lead - i.e. I, II, III, AVR, AVL, AVF, V
	Defective connections	Check electrodes and cable connections; repair or replace as required.
	Monitor connected improperly	Make sure monitor connected via Phone-to-Phone cable to ECG MON input connector
	Defective ECG skin amplifier	Use an external ECG monitor connected to the ECG MON input connector to monitor ECG; call Arrow International for service
	Defective waveform display	Use the strip chart recorder or an external monitor connected to the ECG output connector to monitor ECG; call Arrow International for service
	Incorrect ECG Source selected	Check ECG signal source LED. Change source by pressing SELECT key.
AC interference in ECG waveform (50/60Hz interference)	Reference electrode detached	Reattach reference ECG electrode
	Poor electrode contact, attach new electrodes to patient	
	Lead wires close to AC source	Bundle ECG lead wires together and route them close to patient
Noisy ECG	Inappropriate trigger mode selected	Select another trigger mode
	Excessive muscular artifact	Check electrode contacts and disposable electrode sites; place electrodes on bony prominences
	Skin inadequately prepared	Repeat skin preparation, then apply new electrodes
	Electrodes placed improperly	Apply new electrodes to proper locations
		Verify proper electrical grounding. Disconnect from AC power. If ECG signal quality improves, connect IABP to another AC outlet.

4. Troubleshooting

4.1: Common Operational Problems

COMMON OPERATIONAL PROBLEMS		
Problem	Possible Cause(s)	Corrective Actions
Wandering ECG baseline	Poor electrode contact	Attach new electrodes
	Respiratory movements picked up by patient cable yoke	Move the patient cable yoke away from the abdomen and ventilator equipment Consider use of MAN GAIN until problem can be corrected.
	Electrodes placed improperly	Apply new electrodes to proper locations
No AP waveform displayed	Catheter or needle occluded	Flush and fill the catheter
	Defective transducer	Replace pressure transducer
	Defective amplifier	Use external AP monitor connected to the AP input connector to monitor Arterial Pressure; call Arrow International for service
	Incorrect source selected	Check AP signal source LED. Change source by pressing SELECT key.
	Defective waveform displayed	Use strip chart recorder or an external monitor connected to the the AP output connector to monitor Arterial Pressure; call Arrow International for service
Transducer cannot be zeroed or calibrated	Defective transducer	Replace transducer
	Improper calibration procedure attempted	Disconnect all AP pressure cables and press the CAL key then RESET CAL twice. Reconnect AP cables and follow calibration instructions in Section 7.1
Zero baseline drifts	Defective transducer	Replace transducer
Erratic pressure display	Defective transducer	Replace transducer

4. Troubleshooting

4.1: Common Operational Problems

COMMON OPERATIONAL PROBLEMS			
Problem	Possible Cause(s)	Corrective Actions	
Helium loss	Leak in pneumatic system or in balloon	Perform Leak Test and repair as necessary (Section 4.4)	
	Blood in catheter	Stop pumping and remove balloon immediately	
	Late Deflation	Assess deflation point and adjust earlier.	
	IAB too large	BPW plateau pressure exceeds AUG by more than 25mm—reduce IAB volume.	
	Persistent erratic trigger or arrhythmias	Move deflate earlier, change trigger mode to PEAK, change assist ratio to 1:2.	
COMMON OPERATIONAL PROBLEMS: AutoPilot™ MODE			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Excessive Lead Switching	AutoPilot™	Low voltage ECG	Change to another lead Increase ECG Gain using the > key
		Abnormal or unusual ECG	Change to another ECG lead
		Noisy ECG	Check ECG connections Replace ECG electrodes/cable as needed Change to another lead Select Manual ECG gain Select Operator Mode and select best ECG signal
Incorrect or Wandering Timing	AutoPilot™	Inconsistent triggering	Check trigger selection Select Operator mode and choose consistent trigger mode
		Noisy or poor ECG	Check ECG connections Replace ECG electrodes/cable as needed Change to another lead Select Manual ECG gain
Excessive Trigger switching	AutoPilot™	ECG Noisy Poor ECG waveform quality	Check ECG connections Replace ECG electrodes/cable as needed Change to another lead Select Manual ECG gain
		Changing patient condition	Select Operator mode Select optimal IABP settings

4. Troubleshooting

4.1: Common Operational Problems

Section 1 Troubleshooting the FiberOptix™ System

The following sections provide detailed information on troubleshooting issues with the Fiber Optic system. Subsequent pages list the status messages that may be viewed by pressing HOME then SHOW STATS. These codes provide the current operational status of the FOS electronics, connections and sensor. A description of the code, possible alarms associated with that status code and the issues which may result in the code being displayed are shown. Subsequent pages show possible symptoms, the possible related status codes, possible causes and recommended troubleshooting actions.

NOTE: In all cases, if the Fiber optic system is or becomes non-operational, an alternate AP source will be selected by Autopilot. If Operator mode is selected, an alternate AP source should be selected by the user.

NOTE: The loss of the fiber optic signal does not impair functionality of the IABP system.

Section 2 Fiber Optic Status Codes

This section details the status messages that are issued by the Fiber optic system. They are designed to verify the current FOS status and assist in providing specific information for troubleshooting FOS issues.

FOS Status Codes			
Status Code	Description	Possible Alarm	Possible issues
OK	FOS electronics and sensor are working properly and ready for use.	None	*None
NO COMM	No communication between CPU and FOS electronics	System Error 8	*FOS PCB failure *FOS PCB or CPU cable disconnect *Loss of power to FOS PCB *CPU failure
LL	Low light return	AP FOS Weak Signal	*Sensor not fully connected *FOS cable is damaged or broken *Connections are dirty *Connection is damaged *FOS board failure
SL	Strong light	AP FOS Signal Out of Range	*Sensor not properly connected *Connections are dirty *Connection is damaged
CK	Cal key missing or data is corrupt	AP FOS CAL Key Missing or Corrupt	*CAL key not connected *CAL key data corrupt Ribbon cable loose or disconnected

4. Troubleshooting

4.1: Common Operational Problems

FOS Status Codes (continued)			
Status Code	Description	Possible Alarm	Possible issues
TL	FOS electronics outside of operating temperature	AP FOS Signal Out of Range	*FOS warming up at start-up *FOS heating circuit failure *Loss of power to FOS electronics *Air conduit blocked
BL	FOS is measuring Barometric pressure outside of operating range	AP FOS Signal Out of Range	*Altitude exceeds 10,000 ft (3050m) *FOS electronics failure
RE	Ratiometric error		*Incorrect calculations *CAL key may be damaged or corrupt *Possible FOS PCB failure
PL	FOS is measuring outside of pressure range	AP FOS Signal Out of Range	*Excessive pressure on sensor *Sensor has been damaged
IE	Instrument Error	System Error 8 or No alarm	*Unspecified error or communication error
EO	Excessive offset: Zeroing procedure resulted in a difference of greater than 25 mmHg from factory Cal	None	*Zero was not completed properly or occurred when the sensor was disconnected or partially connected
LT	Loading Cal Table	None	*If it goes away within 10 seconds, no problem *If it stays longer and the zero does not complete, the key may be damaged, corrupted or the ribbon cable may be disconnected
SZ	Sensor Zeroing	None	*None unless longer than 1 minute (See FOS does not zero section of troubleshooting)
RS	Communication failure	System Error 8	*FOS electronics failure
ST	Self Test: Ongoing Ongoing self test which does not complete	System Error 8	*FOS electronics failure

4. Troubleshooting

4.1: Common Operational Problems

Section 3 Troubleshooting Zeroing Issues with the FOS System

If the FOS sensor is unable to Zero the following information will assist in troubleshooting: The display will show “UNABLE TO AUTOZERO FOS” followed by one of the following messages:

UNABLE TO AUTOZERO FOS		
Message (2nd line)	Possible Cause(s)	Corrective Actions
AP Waveform present	AP Waveform detected IAB in patient Noise on Fiber optic sensor	<ul style="list-style-type: none">• Verify IAB is not inserted• Perform Manual Zero
Check FOS connections	Cal key or FOS sensor partially connected or disconnected	<ul style="list-style-type: none">• Check FOS connections• Disconnect and Reconnect Cal key and sensor <p>NOTE: Autozero will continue if sensor and/or cal key are reconnected.</p>
FOS warming up Wait to Autozero or Press AP Select and AP FOS Zero	FOS electronics are outside of expected operating range	<ul style="list-style-type: none">• Wait for FOS Warming up message to clear• Perform manual zero
Press AP Select and Press AP FOS Zero to Zero	FOS sensor reading a pressure > 20 mmHg LL, CK errors detected Zero completed but AP values read > +/- 2 mmHg Zero could not be completed for unspecified reason	<ul style="list-style-type: none">• Check FOS connections• Perform manual zero

If none of the corrective actions resolve the issue, perform the Manual zero or switch to an alternate AP source.

4. Troubleshooting

4.1: Common Operational Problems

Section 4 Fiber Optic General Troubleshooting Information

This section shows symptoms that may occur when using the Fiber optic system. The expected or related FOS status code is shown, potential causes are detailed and recommended solutions are given. Some actions may be done by the user. Those items shown in *Italics* should be performed by qualified service personnel.

FiberOptix™ GENERAL TROUBLESHOOTING			
Problem	FOS Status Code	Possible Cause(s)	Recommended Solutions
No signal is displayed	LL	Sensor not connected	Disconnect and reconnect sensor
		Sensor or FOS cable damaged	Replace IAB Use an Alternate AP source
		Optical sensor interface is dirty	Change optical sensor block Call field service
	RL or PL	Signal is out of display range Above altitude limit	Use MAP CAL to adjust FOS MAP Use alternate AP source Reduce altitude if > than 10,000 ft (3050m)
	TL	Temperature is outside of operating limits	Wait until temperature is within operating range Use alternate AP source Call Field service if problem persists
Inaccurate AP hemodynamic readings	LL or SL	Optical signal not fully transmitted	Use FOS MAP cal to adjust signal Use alternate AP source for treatment decisions
Noisy signal	No specific Code	IAB catheter whip	Check IAB position Reposition as needed
FOS Does not Zero	LL	Sensor not fully connected	*Remove blue slide then reconnect *Verify 2 clicks and audible tone are heard Sensor should zero with 1 minute (average 15 seconds)
	LL	Sensor cable damaged or broken	Use alternate AP source Replace IAB
	LL	Sensor interface block is dirty or damaged	*Clean FOS connector using procedure recommended in Chap 10 *Replace FOS track assembly *Call Field Service

4. Troubleshooting

4.1: Common Operational Problems

FiberOptix™ GENERAL TROUBLESHOOTING			
Problem	FOS Status Code	Possible Cause(s)	Recommended Solutions
FOS light bulb turns Green in < 10 seconds or on Connection of a new IAB FOS sensor	CK	Cal key not connected or corrupt	*Connect Cal key *Disconnect then reconnect Cal key *Replace IAB *Check cable connected to rear of CAL key front panel connector *Replace IABP* Call field service.
	TL	FOS electronics are outside of operating temperature range	*Wait up to 5 minutes for message to clear *Insert IAB without zeroing (Use FOS MAP Cal function is numerical values are not accurate) *Call field service
	LT	Cal table loading Loading error	*Wait up to 20 seconds for Cal data to load *Remove/reconnect Cal key and FOS Sensor *Replace IAB *Exchange IABP console *Call field service if problem occurs on more than one FOS cal key
	EO	Current sensor has either been connected and zeroed prior or sensor did not zero correctly	*If IAB is not inserted, insert another CAL key, when light bulb changes to Blue, disconnect CAL key and re-insert the CAL key that is attached to the IAB. The sensor should zero properly

4. Troubleshooting

4.1: Common Operational Problems

ESIS

ESIS minimizes the interference problems caused by electrosurgical/cautery devices. However, some ESU devices cause more severe interference problems than others: in some cases, particularly with older cautery systems, completely eliminating interference with the ECG waveform may not be possible. The table below provides suggestions for correcting excessive interference problems.

TROUBLESHOOTING ESIS		
Problem	Possible Cause(s)	Corrective Actions
Persistent electrosurgical interference	Poor ECG lead contact	<ul style="list-style-type: none"> • Check electrode-to-skin contact; reattach electrode if necessary • Check connections at lead tip and cable junctions; repair if necessary • Replace the ECG cable • Use back pad electrode
CAUTION: ESIS is operational at all times, however, it is most effective when a five-lead ECG cable is used	Incorrect ECG lead selected	Change lead selection in the ECG SOURCE SELECT section of the keypad
	Lead wires positioned improperly	Place lead wires so they are away from the electrocautery cable and at a 90° angle from the cables
	High electrocautery setting	<ul style="list-style-type: none"> • Use minimum ESU required for adequate cutting and setting • Change to AP trigger mode
	Ground plate positioned improperly	Place ground plate under back and under the surgical site
Persistent electrosurgical interference	Electrodes placed on patient improperly	Change electrode placement (leads may be placed on the posterior aspect across the shoulder axis if necessary); check lead selection
Persistent electrosurgical interference	Cables placed improperly	Place cables so they are away from the electrocautery cable and at a 90° angle from the cables
Display scrambled or corrupted	Excessive ESU Interference	Disconnect cable from LCD unit momentarily and reattach

4. Troubleshooting

4.1: Common Operational Problems

TROUBLESHOOTING ESIS		
Problem	Possible Cause(s)	Corrective Actions
Absent or poor ECG waveform	ECG Cable connected improperly	Make sure the ECG cable is connected to the correct connector on the AutoCAT®2 (Section 5.1)
	Poor ECG lead contact	<ul style="list-style-type: none">• Check electrode-to-skin contact; reattach electrodes if necessary
	Incorrect lead selected	<ul style="list-style-type: none">• Check connections at lead tip and cable junctions; repair if necessary
	ECG source improperly selected	<ul style="list-style-type: none">• Check ECG source and change if needed
	Electrodes placed on patient improperly	Check electrode placement (leads may be placed on the posterior aspect across the shoulder axis if necessary); check lead selection
Intermittent or absent flashing heart or white trigger bands	Inappropriate trigger mode selected	Change trigger mode
	ECG Gain affected by ESIS interference	Consider using MAN GAIN

4.2 Diagnostic Alarms

The AutoCAT®2 Series alarm system notifies you of certain potential or actual problems and suggests corrective steps: always respond to alarms promptly. The tables on the following pages provides additional information about the automatic response and information only alarms.

1. To disable alarms, press **ALARMS ON/OFF** key. Select the amount of time for **ALARMS OFF** (10 to 60 minute increments). The time remaining for the **ALARMS OFF** period will be displayed to the left of the ECG. A warning message will appear above the ECG.
2. To change the audio level, select **AUDIO LEVEL** in the multi-function keys of the keypad and adjust appropriately.

WARNING Do not turn off alarms except for brief period while correcting an alarm condition. After the alarm condition has been corrected, enable the alarms by pressing the ALARMS ON control key.

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
System Error 1 Incorrect Pressure Level	AutoPilot™ Operator	Pneumatic pressure level out of range.	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON. If alarm persists, change IABP console. Call field service.
System Error 3 Pump/Valve Controller Failure	AutoPilot™ Operator	Pneumatic system failure	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON. If alarm persists, change IABP console. Call field service.
System Error 4 Main CPU Failure	AutoPilot™ Operator	Computer failure	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON. If alarm persists, change IABP console. Call field service.

4. Troubleshooting

4.2: Troubleshooting Alarms Class I

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
System Error 6	AutoPilot™ Operator	CPU failure	Press Alarm reset. Press pump ON to resume pumping. If this does not correct problem then turn power OFF then ON. If alarm persists, change IABP console. Call field service.
System Error 7 Keyboard Controller Failure	AutoPilot™ Operator	Umbilical cable disconnected at control head or at console.	Check umbilical cable connections. Reconnect as needed. If alarm persists, power the pump OFF then ON.
		Control head hardware failure	Change control heads or IABP console. Call field service.
System Error 8 (AutoCAT®2 WAVE® Only)	AutoPilot™ Operator AutoCAT®2 WAVE only	FiberOptix™ hardware failure	Change IABP console. Call field service. Select an alternate Arterial pressure source. If problem persists, turn pump OFF then ON.
Unable to Refill	AutoPilot™ Operator	Low Helium tank pressure	Check HE tank. Change as needed.
		Fill/Drain valves malfunctioning	Change IABP console and call field service.
		Insufficient deflation time	Check timing. If deflation time is very short, i.e. there is no visible BPW baseline, switch to Operator mode.
Unable to Refill	Operator	Incorrect timing	Verify Operator mode. Adjust timing until BPW baseline is visible during IAB deflation. If problem persists, select 1:2 assist ratio. Change IABP console

4. Troubleshooting

4.2: Troubleshooting Alarms Class I

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Possible Helium Loss	AutoPilot™ Operator	Leak in Tubing or Connections	Perform Leak test and repair tubing as needed
		Kinked Catheter	Find kink and straighten out the catheter
		IAB has not fully exited the sheath	Be sure the IAB has exited the sheath
		Balloon connector not properly seated	Disconnect and reconnect the IAB connector
		Blood in catheter tubing	Remove balloon immediately and insert a new IAB catheter
			WARNING Any evidence of blood leakage within the IAB assembly warrants immediate IAB removal.
		IAB too large	Reduce IAB volume
		Erratic triggering or arrhythmias Incorrect timing	Change assist ratio to 1:2 Reduce IAB volume. Select Operator mode and select PEAK trigger and reset timing
		Very late deflation or early inflation	Change to 1:2 assist. If alarm condition does not occur, return to 1:1 and adjust timing so BPW baseline may be observed. NOTE: If HE loss continues in 1:2 assist, perform leak test.
		Erratic triggering or arrhythmia's	Change to PEAK trigger mode. Set deflation earlier.
High Pressure	AutoPilot™ Operator	Kinked IAB Driveline	Check tubing for kinks. Find and straighten kink.
		IAB has not exited the sheath	Verify IAB is out of sheath. Reposition IAB as needed.

4. Troubleshooting

4.2: Troubleshooting Alarms Class I

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
High Baseline	AutoPilot™ Operator	Partially wrapped IAB	Notify physician; aspirate IAB, if no blood is present inject 50cc of air into the balloon and aspirate and remove syringe from IAB connector.
		Balloon Too Large for the Aorta	Check BPW/AP relationship. Decrease IAB volume if indicated.
		Kinked catheter	Find kink and straighten out catheter.
		IAB has not exited the sheath	Verify IAB is out of sheath. Reposition IAB as needed.
		Partially wrapped balloon	Notify physician; aspirate IAB, if no blood is present inject 50cc of air into the balloon and aspirate immediately.
		Overfill	Call Arrow International for service
Large Helium Leak	AutoPilot™ Operator	Improper IAB position	Verify IAB position and reposition as needed.
		IAB tubing disconnected or IAB disconnected from console	Check all IAB connections for leak. Reconnect and/or tighten as needed.
		Quick connection on IAB is not tightly connected	Tighten quick connection
		Leak at IAB connection or in Tygon tubing between console and catheter insertion point.	Verify tight connections at all driveline tubing connection points.
		Other helium leak	Perform leak test. Replace or repair IAB as needed. Check for blood in tubing. If blood is observed remove and replace IAB. If no blood is observed, perform leak test.

4. Troubleshooting

4.2: Troubleshooting Alarms Class I/II

AUTOMATIC RESPONSE ALARMS (Class I)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Purge Failure	AutoPilot™ Operator	No trigger or reliable trigger signal lost.	Check patient. Verify trigger bands are present on ECG and AP. Verify flashing heart and HR corresponds to patient. Select Operator mode and choose appropriate trigger mode.
		Helium tank not open or inserted properly.	Check helium tank. Change as needed.
		Helium tank empty.	Replace HE tank
		Prior alarms not reset.	Verify alarms are reset. Reset alarms as needed.
		IAB not connected	Check IAB connections Attach IAB connector.
AUTOMATIC RESPONSE ALARMS (Class II)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Standby Alarm Disabled	AutoPilot™ Operator	Stand-by alarm disabled indefinitely	Press pump OFF. Press pump ON to resume counterpulsation.
Standby longer than 3 MIN	AutoPilot™ Operator	Pump in standby for longer than 3 minutes	<ul style="list-style-type: none"> • Press RESET to clear alarm (Alarm will be re-issued in 3 minutes) • Press pump OFF • Press pump ON to resume counterpulsation • Press Pump Stand-by Twice to place pump in Stand-by mode indefinitely.

4. Troubleshooting

4.2: Troubleshooting Alarms Class II

AUTOMATIC RESPONSE ALARMS (Class II)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
ECG Trigger Loss	Operator only	No ECG waveform displayed	<ul style="list-style-type: none"> • Check patient condition/rhythm. • Check electrode placement and change if necessary. • Check ECG cable connections; reconnect as needed. • Check external monitor connection at monitor and IABP input. • Check/change ECG lead. • Check/change ECG source.
		Waveform erratic or noisy	Reapply electrode paste or disposable electrodes. Consider using Manual gain
		Low waveform amplitude or biphasic QRS complexes	Select another lead (if using external monitor, change lead on monitor). Increase size using gain controls.
		Inappropriate trigger mode selected.	Select another trigger mode and reset timing as needed.
Pressure Trigger Loss	Operator only	No pressure waveform displayed	<ul style="list-style-type: none"> • Check patient condition • Check all connections. Make sure correct AP Select source is selected. <ul style="list-style-type: none"> • Check pressure transducer, IAB catheter and connections for loose connections, repair/tighten if necessary. • Select another trigger mode. • Re-Zero AP source.
	FiberOptix™ AP sensor (AutoCAT®2 WAVE® only)	AP sensor cable disconnected	Check connections and reconnect as needed. 2 beep tone confirms connection is made.
		AP sensor cable broken	Replace IAB. Select an alternate AP source.

4. Troubleshooting
4.2: Troubleshooting Alarms Class II

AUTOMATIC RESPONSE ALARMS (Class II)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
ECG Lead Fault Detected	AutoPilot™ Operator	CAL key not inserted or corrupted.	Insert CAL key. Change IAB catheter. Use alternate AP source.
		FiberOptix™ connector needs to be replaced or cleaned.	Replace FiberOptix™ connection. Clean FiberOptix™ sensor connection point. Call field service.
		FiberOptix™ electronics failure.	Replace console. Use an alternate AP source. Call field service.
		FiberOptix™ electronic temperature out of range.	Replace console. Use an alternate AP source. Call field service.
		Altitude above 10,000 ft. (5030 M)	Use alternate AP source.
		Poor electrode connection	Re-apply electrode paste or replace disposable electrodes
		Loose connections	Check ECG cable connections; repair/reconnect as needed. Replace ECG cable.
Trigger Loss	AutoPilot™ only	3 lead cable detected	Use 5 lead ECG cables only
		Phono to Nicolay cable detected	Use a Phone to Phone cable for slaving
		No ECG/AP/Pacer trigger can be found	Check patient condition Switch to Operator mode Check ECG/AP sources and change as needed.
		Very small ECG signal	Use ECG gain to increase ECG size.

4. Troubleshooting

4.2: Troubleshooting Alarms Class II/III

INFORMATION ONLY ALARMS (Class III)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
AP FOS Signal Weak	AutoPilot™ Operator	AP sensor failure	Cable is broken. Replace IAB. Select an alternate AP source.
		AP sensor dirty	Clean FiberOptix™ AP contact point. Replace FiberOptix™ sensor contact.
		AP sensor partially connected	Disconnect and then reconnect AP FiberOptix™ sensor. Verify 2 beep tone is heard when sensor is connected.
AP FOS Sensor Out of Range	AutoPilot™ Operator	Electronics operating temperature too high or too low.	Select an alternate AP source.
		Altitude above 10,000 ft. (5030 M)	Change altitude. Select an alternate AP source.
AP FOS Cal key missing or Corrupt	AutoPilot™ Operator	AP FiberOptix™ key not plugged into receptacle	Reconnect CAL key
		AP FiberOptix™ CAL key damaged	Replace IAB. Select an alternate AP source.
Drain Failure	AutoPilot™ Operator	Condensate bottle full	Empty condensate bottle
		Drain tubing kinked	Straighten drain tubing
		Drain valve failed to open or system purge not performed	Initiate purge cycle by pressing PUMP OFF then Stand-by, wait 5 seconds for purge, then press PUMP ON to resume pumping. Replace IABP console. Call field service.
Deflate Marker Beyond 100%	Operator only	Deflation set beyond the R wave	Check deflation timing. Set deflation earlier as needed.
Insufficient time to inflate	AutoPilot™ Operator	Timing may be incorrect	Check timing. Select Operator mode and adjust timing

4. Troubleshooting

4.2: Troubleshooting Alarms Class III

INFORMATION ONLY ALARMS (Class III)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Warning: Battery Inoperative	AutoPilot™ Operator	The AutoCAT® 2 will not run in battery mode due to faulty circuit breaker	Do not disconnect the AutoCAT® 2 from AC power source. Check circuit breaker located in helium compartment.
		Circuit breaker turned OFF	Turn on circuit breaker
Available Battery Power Less than 5 minutes	AutoPilot™ Operator	Battery voltage low	Change to AC power as soon as possible to recharge batteries
Available Battery Power Less than 10 minutes	AutoPilot™ Operator	Battery voltage low	Change to AC power as soon as possible to recharge batteries
Available Battery Power Less than 20 minutes	AutoPilot™ Operator	Battery voltage low	Change to AC power as soon as possible to recharge batteries
System Running on Battery Power	AutoPilot™ Operator	AC power disconnected	Check AC power source. Reconnect the IABP to AC power
		AC power failure	Arrange for alternate AC power source if failure is expected to exceed 90 minutes. If AC power is connected but not available, change IABP console. Call field service.
Possible ECG Trigger Detected	Operator	QRS complex detected while in INT mode.	Verify ECG is present. Change to ECG or AP trigger mode.
Weaning Step Complete	AutoPilot™ Operator	Weaning timer has expired	Evaluate patient hemodynamics and set parameters for next weaning step. If weaning is complete, remove IAB.

4. Troubleshooting

4.2: Troubleshooting Alarms Class IV

INFORMATION ONLY ALARMS (Class III)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Arterial Pressure Alarm	AutoPilot™ Operator	AP has fallen below set limit	Check patient hemodynamics. Check for AP disconnect.
Low Helium Tank Pressure	AutoPilot™ Operator	HE tank is empty	Change HE tank
		HE tank is OFF	Open HE tank
AUTOMATIC ALERTS ALARMS (Class IV)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
Possible Late Deflation	AutoPilot™	Electromechanical delay is less than 100 msec	Check deflation timing. If deflation timing is too late and patient hemodynamics are compromised, select Operator mode and manually adjust timing
Erratic Triggering	AutoPilot™	ECG connected from bedside monitor. Signal delay is longer than 35 msec	Consider using direct patient connection with 5 lead ECG cable.
		> 3 lead switches within 1 minute and no AP signal available	Check ECG signal quality. Change ECG electrodes. Change ECG lead. Adjust Autogain or select Man gain. Select Operator mode.
		Noisy ECG signal	
		> 3 trigger switches between AP and Pacer within 1 minute	Check patient condition. Select Operator mode. Select appropriate trigger mode.
No ECG signal available	AutoPilot™	ECG signal is not available but IABP is triggering on AP or pacer signal	Check ECG connections. Reconnect ECG cable or leads. Attach another ECG source from patient or monitor.

4. Troubleshooting

4.3: Balloon Pressure Waveform

AUTOMATIC ALERTS ALARMS (Class IV)			
Problem	Operation Mode	Possible Cause(s)	Corrective Actions
No AP signal Available	AutoPilot™	AP signal is not available, but IABP is triggering on ECG or pacer signal	Check AP connections. Reconnect AP cable. Attach another AP source from patient or monitor.
ECG Lead Fault	AutoPilot™	ECG electrode disconnect	ECG lead or cable disconnect but pump is pumping in an alternate trigger mode. Check ECG lead contact. Check ECG cable/lead connections. Reconnect ECG cable/lead. Replace ECG electrodes.
		3 lead cable detected	Use 5 lead ECG cables only
		Phono to Nicolay cable detected	Use a Phone to Phone cable for slaving
Arrhythmia Timing Not available	AutoPilot™	ECG signal is noisy PEAK trigger is not stable or available	Check ECG signal Change to another ECG Lead Check ECG lead contact Re-apply or move electrodes on patient Check/Replace ECG cable if damaged Select Manual Gain Select Operator mode and select another trigger mode
Warning: Dead Clock Battery	AutoPilot™ Operator	Internal Clock Battery Malfunction Call Field Service	Call Field Service Pump can remain on patient.
Warning: Low battery for static RAM	AutoPilot™ Operator	Internal Static RAM Battery Malfunction	Call Field Service Pump can remain on patient.

4. Troubleshooting

4.3: Balloon Pressure Waveform

4.3 Balloon Pressure Waveform

The balloon pressure waveform displayed on the AutoCAT®2 LCD represents the dynamic actions of the helium shuttle gas during pumping. A properly functioning balloon usually produces the balloon pressure waveform and AP waveform shown in Figure 4.1.

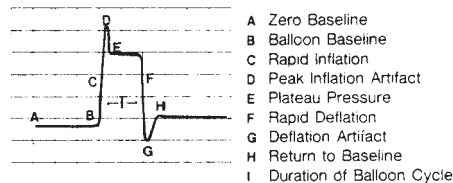


Figure 4.1: Normal Balloon Pressure Waveform

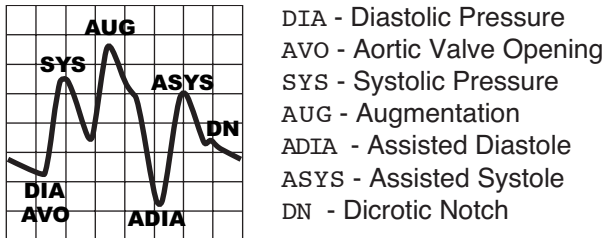


Figure 4.2: Properly Timed Arterial Pressure Waveform

Problems with the control system, IAB problems or certain patient conditions can cause distortions in the balloon pressure waveform. Troubleshooting these waveforms is often the best way to recognize and correct problems. Being familiar with the waveforms in this section can help you maximize the clinical benefits of IABP to the patient.

Some of the abnormal balloon pressure waveforms in this section may initiate one or more alarms. This is because the AutoCAT®2 detects abnormally high or low balloon pressure, helium loss and catheter or tubing obstructions by monitoring balloon pressure. By monitoring the patient's status as well, the AutoCAT®2 Series can identify balloon occlusion and reduced augmentation.

The BPW plateau has a normal and expected relationship to the AUG of the patient. The BPW plateau and AUG should be within 20-25 mmHg of each other. You may want to use the cursor to verify the BPW plateau pressure.

Squared Waveform

Three causes of a squared balloon pressure waveform (Figure 4.3) are listed below.

1. There is a kink in the catheter, sheath or balloon membrane.

Examine the catheter for kinks, then straighten out the catheter. Verify that the IAB membrane has completely exited the insertion sheath.

2. The balloon has not unwrapped.

Notify the physician. Aspirate approximately 50 cc of air then inject approximately 50 cc of air into the balloon connector and aspirate or disconnect the syringe from the IAB connector.

3. The IAB is occlusive.

Select **BALLOON VOLUME** and decrease the balloon inflation volume. Observe the balloon pressure waveform. Repeat this procedure until the waveform appears normal.

WARNING

If an IAB is suspected of being occlusive, do not reduce the IAB volume to less than 2/3 of the balloon's capacity. To prevent thrombus formation, pump the balloon at maximum capacity for five minutes every hour. A smaller IAB volume should be considered.

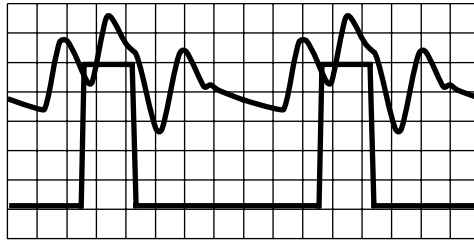


Figure 4.3: Squared Balloon Pressure Waveform

Reduced Augmentation

Reduced augmentation may result in a waveform characterized by a “low plateau pressure” (see Figure 4.4). Some causes of reduced augmentation are listed below.

1. **Balloon too small -**
Forward displacement of blood will be decreased since the blood will also be driven around the balloon.
2. **Balloon positioned too low -**
If the balloon is too low there is more area to try to displace volume and the balloon is not as effective.
3. **Hypovolemia or Patient is ready to wean from the IABP -**
Rationale: Best augmentation occurs when the patients stroke volume equals the balloon volume, ie. 40cc balloon will work best when patients stroke volume is 40cc's. If the stroke volume goes above or below the balloon volume the augmentation will decrease.
4. **Balloon is not unwrapped -**
If the balloon is not fully unwrapped it will be unable to displace the full volume and therefore augmentation will decrease.

4. Troubleshooting

4.3: Balloon Pressure Waveform

5. Late inflation -

When inflation occurs at the beginning of diastole there is a lot of blood in the aorta because systole has just occurred. If the balloon inflates too late, the blood in the aorta will run off into the periphery and therefore will not have as much volume to displace.

6. Balloon positioned in the wall of the aorta instead of the vessel -

This would cause a false aneurysm, and the patient would most likely experience severe back pain. This would cause a decrease in augmentation because there would be minimal, if any, displacement of blood.

7. Balloon volume not set at desired value -

All pumps automatically set volume when balloon is connected, however the balloon volume may have been decreased and not returned to full volume.

8. Low systemic vascular resistance (SVR).

9. Obstruction to gas flow -

Kinks in the driveline tubing or IAB catheter may obstruct flow to the balloon and reduce augmentation.

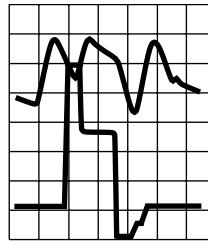


Figure 4.4: Balloon Pressure Waveform Reflecting with Arterial pressure Waveform showing reduced augmentation

Baseline Below Zero

If the baseline of the balloon pressure waveform falls below zero as shown in Figure 4.5, there is probably a helium loss. The AutoCAT®2 will initiate the POSSIBLE HELIUM LOSS or LARGE HELIUM LEAK alarm (unless the system is in the ALARMS OFF mode). To correct this problem:

1. Press PUMP OFF to stop the pump.
2. Perform the Leak Test (Section 4.4) and repair any leaks found. Do not resume pumping until leaks have been corrected.

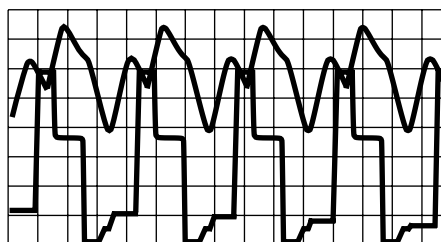


Figure 4.5: Balloon Pressure Baseline Below Baseline

4.4 Leak Testing and Tubing Repairs

If a helium leak is suspected, follow the instructions below to check the pneumatics and the balloon connector. You will need a pair of rubber-shod hemostats and a spare balloon connector and tubing to perform the Leak Test. Call your Arrow International Sales Representative or service number for ordering information.

Leak Test

1. Press the RESET control key in the ALARMS field to silence any audible alarms.
2. Press the ALARMS ON/OFF control key and select the 10 MIN key to disable the alarms for ten minutes.
3. Use a pair of rubber-shod hemostats or other clamping device to clamp the catheter tubing between the quick connect valve and the bifurcation.
4. Press the ON control key to start pumping.
5. Observe the balloon pressure waveform. If the baseline falls, the leak is probably between the pump and the clamp. If the baseline does not fall, the leak is probably on the patient side: consider stopping the pump, removing the balloon catheter and inserting another catheter.
6. Press the PUMP OFF control key and remove the hemostat.
7. Check the 0-rings on the balloon connector, wipe off any debris and make sure that the connection at the quick connect valve at the IAB catheter bifurcation is tight.

Also, examine the tubing at the balloon connector and at the catheter junction. If the tubing appears to be stretched in either location, see the instructions below to repair the tubing.
8. Repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, the leak is in the control system or the connector. Complete steps 9-10.
9. Press the PUMP OFF control key and remove the hemostat.
10. Remove the balloon connector, cut off 1/2" of tubing, replace the connector and repeat steps 2-4. If the baseline remains steady, the leak has been corrected and you can resume pumping. If the baseline continues to fall, there may be an internal console leak. Call Arrow International for service.
11. If the alarms are still disabled, press the ON control key to re-enable the alarms.
12. Press ALARM RESET to remove alarm messages.

4. Troubleshooting

4.4: *Leak Testing and Tubing Repairs*

Tubing Repairs

1. To repair a tubing leak, wrap non-porous tape (e.g., electrical tape) around the tubing at the site of the leak.
2. To repair stretched tubing at the balloon connector, remove the compression ring and pull the connector off the tubing. Then cut off a 1/2 inch segment from the end of the tubing and reconnect the balloon connector and the compression ring.
3. To repair stretched tubing at the catheter junction, disconnect the tubing from the junction. Then cut a 1/2 inch segment from the end of the tubing and reassemble the junction.

If the leak is found at the QUICK CONNECT, an occlusive, clear dressing material may be used to repair the leak.